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(54) Vehicle location system

(57) A vehicle location system for location of vehicles within an area having regions (A) within which travel from one location to another is relatively unrestricted but travel between one region and another is possible only via a relatively restricted number of routes, operates in accordance with the principle of dead-reckoning navigation, in which, when passing by specific points the vehicle is supplied via radio beacons BK with a precise location identification on which the continued dead-reckoning navigation is based. The dead reckoning and beacon data are transmitted to a central control station over the radio telephone link, when central station interrogates mobile equipment by radioing an appropriately code signal.

FIG 1

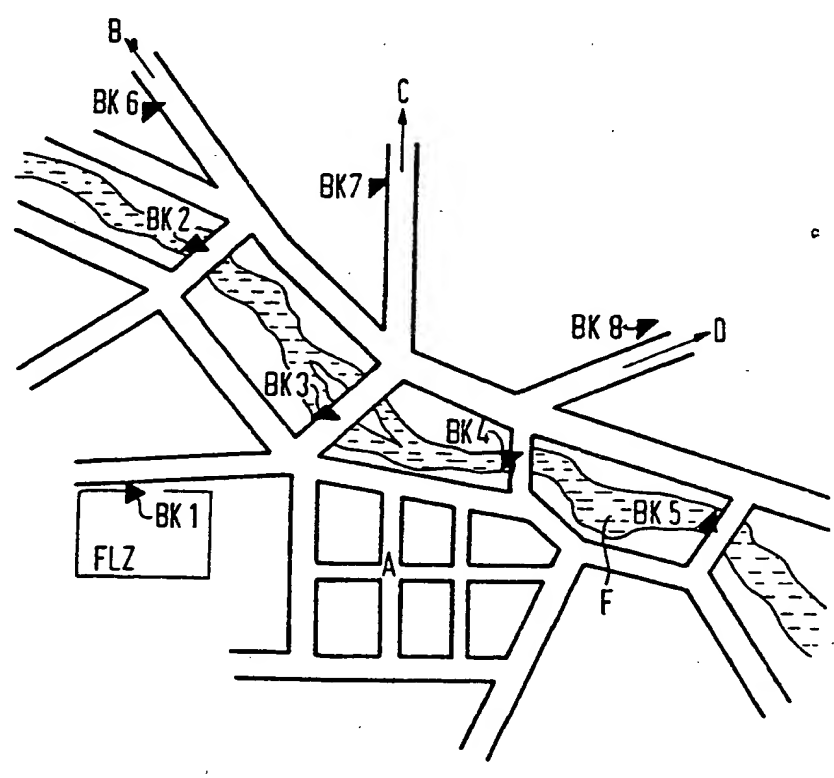

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FIG 1

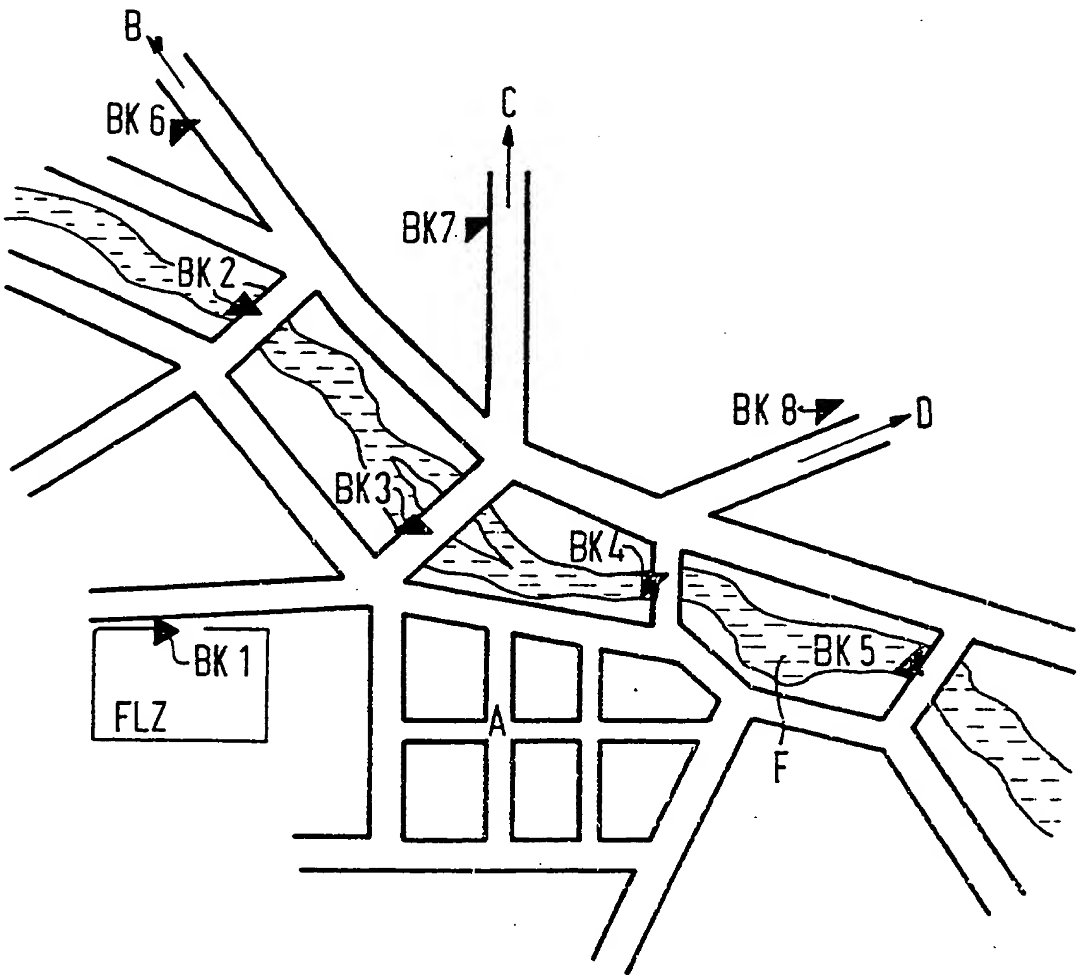


FIG 2

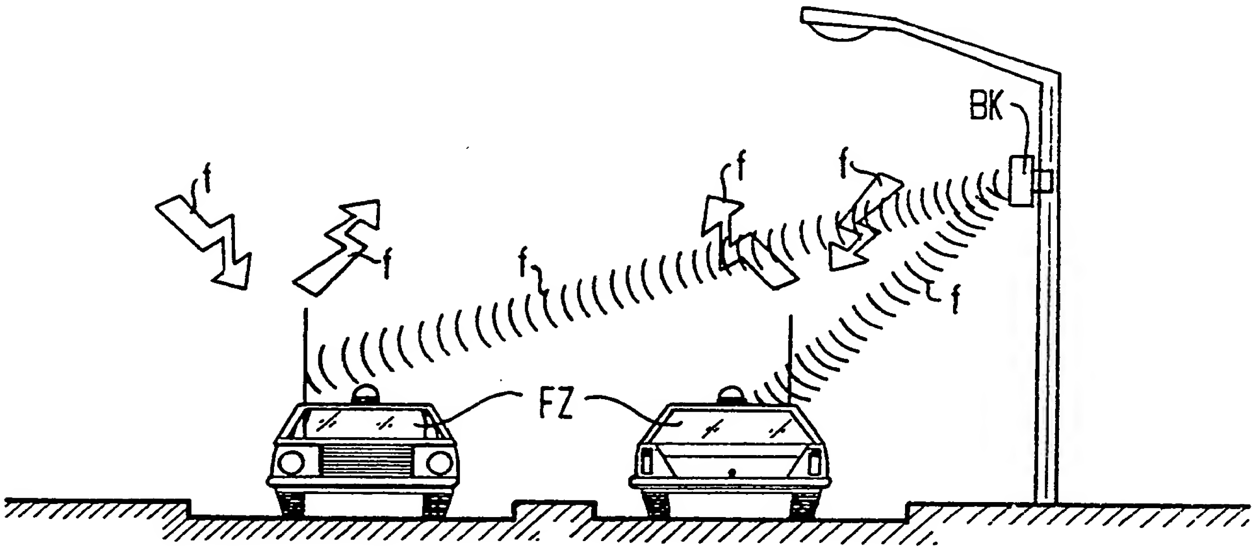


FIG 3

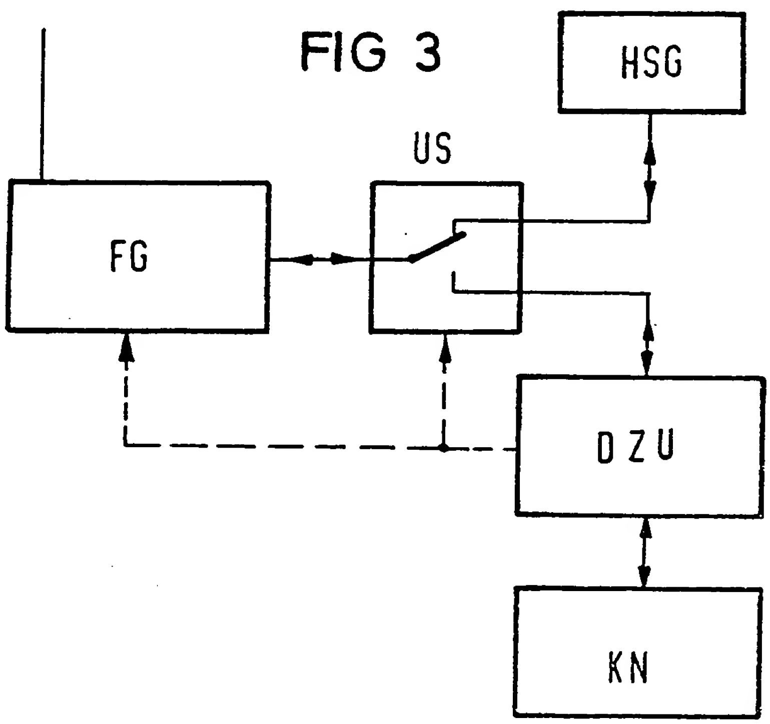


FIG 4

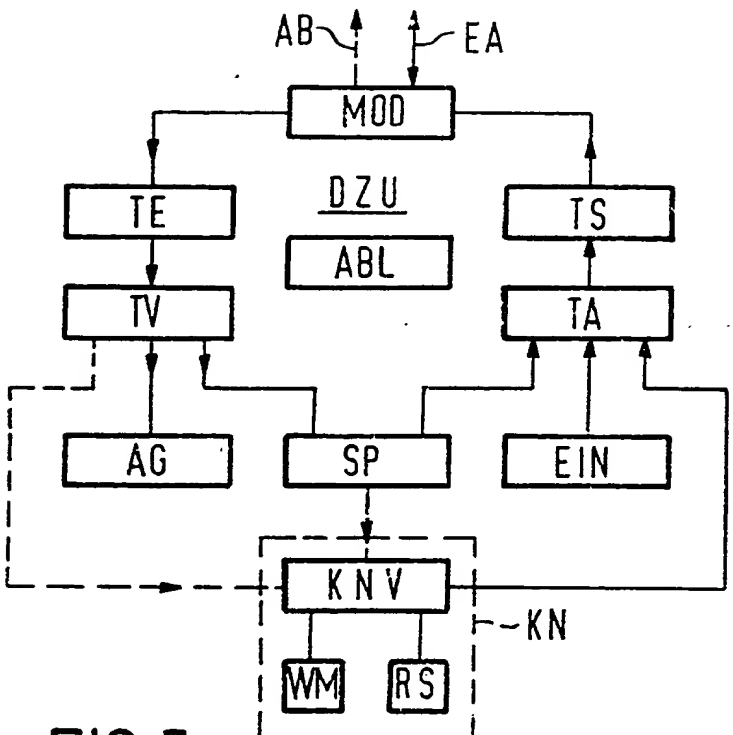
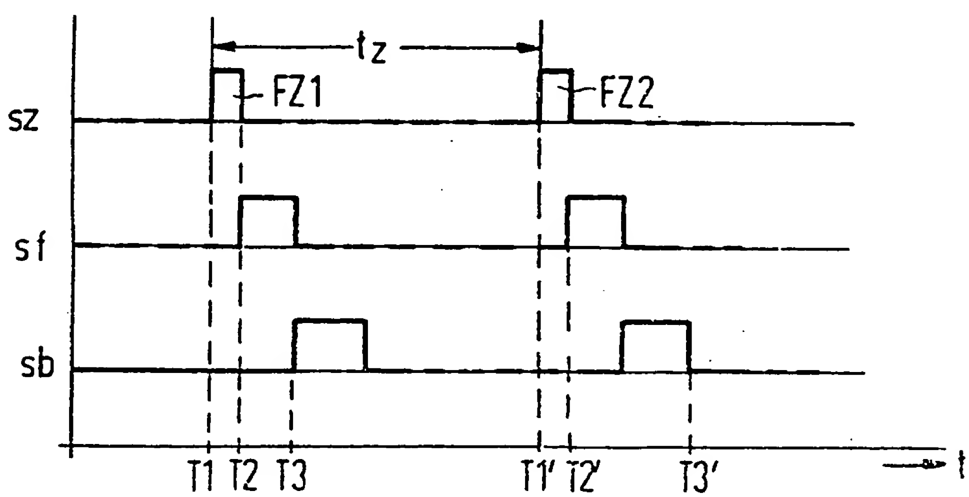

AB
EA
MOD
DZU
TE
TS
ABL
TV
TA
AG
SP
EIN
KNV
KN
WM
RS

FIG 5


tz
FZ1
FZ2
sz
sf
sb
T1 T2 T3
T1' T2'
T3'
t

SPECIFICATION

Vehicle location system

The invention relates to systems for determining the location of vehicles.

Traffic control systems for efficient management of fleets of vehicles require that the location of all vehicles in the overall operations zone should be precisely determined. The function of these control systems is to provide an effective service, especially in extensive urban zones, for example for the police force, fire brigade and other emergency services, but also for short-distance transport systems and taxi services. Various means have already become known for locating vehicles in areas of this kind, for example the hyperbolic method, the dead-reckoning navigation method, and the beacon locating method (see IEEE Trans. Vehicular Technol. 26 May 1977, page 187 to 191). All these known locating methods can also be applied in an urban area, but they are each characterised by certain sources of error. Therefore the use of one single locating system frequently leads to inaccurate measurements unless the errors are eliminated at a high cost outlay.

The dead reckoning navigation process can generally be employed extremely successfully for position finding in an urban area. Here the position finding is carried out on board the vehicle by means of direction finding sensors, for example a magnetic probe or a gyrocompass, and an odometer. An absolute determination of the location requires exact positioning at the beginning of the process and regular corrections in dependence upon the required degree of accuracy, as the position finding errors are cumulative. In the case of the beacon location process, beacons are erected over the entire zone of interest, and a vehicle which passes by these beacons receives the precise location information location-selectively via a receiver. This system can operate with any desired degree of accuracy using a dense network of beacons, but generally speaking it can only be used effectively for fleets of vehicles which use fixed routes, for example short distance transport systems in which the beacons are erected along fixed omnibus routes. For more general applications the outlay in respect of beacons would be too high.

In addition it has also already been proposed to combine a dead-reckoning navigation process with the beacon position finding process in that at predetermined points within the locating zone the beacons provide a new zero point for continued dead-reckoning navigation. However, a combination of this kind in accordance with previous proposals likewise requires a high outlay since costs are incurred for equipment for both position finding systems.

According to the present invention there is provided a vehicle location system for location of vehicles within an area having regions within which travel from one location to another is relatively unrestricted but travel between one region and another is possible only via a relatively restricted number of routes, comprising a central control station, a navigation device in each vehicle and operable to determine the direction and distance of travel of the vehicle, radio beacons sited only at positions adjacent said routes whereby whenever a vehicle travels between regions it passes within range of the corresponding beacon, radio apparatus in each vehicle operable to receive identification signals from a beacon when within range thereof and to transmit location information to the central control station, and means, either within each vehicle or in the central control station, operable to continually calculate vehicle location by dead reckoning, using the distance and direction information fron the navigation device, relative to a reference position identified by the last beacon (if any) to have been passed, or (if none) a starting position.

The radio apparatus will include a data set which primarily serves to connect the dead-reckoning navigation equipment. In order to exploit the radio beacons, it can also include facilities for intermediately storing the beacon identification signal (location identification signal) which has been transmitted from the relevant radio beacon to the vehicle radio apparatus until this signal is possibly further processed and/or transmitted on to the central control together with the dead-reckoning navigation data. Here it can be advantageous to use the same radio channel for beacon interrogation and vehicle/control data transmission, whilst the speech traffic is handled via one or more further radio channel(s). It is then possible for position finding to be carried out continuously and for only the vehicle (in the case of one speech channel) or the few vehicles (in the case of a plurality of speech channels) which is/are currently engaged in speech to be excluded from the position finding process. In small systems it is also possible to use one common radio channel for data and speech. In this case position finding can be carried out only during the intervals in conversation.

In this combined system the number of radio beacons can be kept relatively small as the dead-reckoning navigation operates sufficiently accurately to ensure that no correction is required provided the vehicle remains within a homogeneous urban area. Readiness for use, for example of a police vehicle, is ensured provided the vehicle can reach a location within a zone unobstructed within a relatively short length of time even when it has travelled at some distance from the last reference point when the position finding may be some-

what inaccurate.

On the other hand, it must be established with greater certainty whether the vehicle within the locating zone lies on one or the other side of an obstacle, for example a river. Therefore it is provided that beacon position finding be carried out at those points at which a vehicle is moving over the boundaries of substantially enclosed areas. A junction point of this kind consists for example of a bridge or a river.

It can be provided for example that all the vehicles are cyclically called up from the central control, and having been called up each vehicle transmits a short telegram to the central control. This telegram can for example contain dead-reckoning navigation data and the location identification of the last beacon to have been passed. If a vehicle which is about to be called up is currently engaged in conversation, the central control will naturally be aware of this fact and call-up can be delayed until the conversation is ended.

Passive beacons can be used for example to obtain the location identifications, in which case an unmodulated carrier can be radiated from the relevant vehicle, received by the nearest beacon, and returned modulated with the location identification of the beacon. In this case the beacon does not contain its own carrier production means; consequently its power consumption is low which means that these beacons can be supplied over a long period of time by means of solar cells or batteries, independently of the mains supply. The modulation device of the beacon can be constantly operated. A further reduction in the power consumption of the beacon can be achieved by providing that the modulation device is not activated until a call-up signal is received from the central control or from a passing vehicle. This can be effected for example by emitting a beacon interrogation command simultaneously to the call-up command during cyclic call-up of the vehicles.

It is of course possible to use active beacons instead, where the beacons emit their location identification at low power either constantly or at predetermined intervals—or one can provide that the transmitting device of the beacon is switched on only upon receipt of a call-up signal: here again the call-up signal can be transmitted via the vehicle or directly from the central control.

An exemplary embodiment of the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 schematically illustrates a zone in which the location of vehicles is to be determined;

Figure 2 illustrates information transmission from and to the vehicles in a schematic view;

Figure 3 is a block circuit diagram of the equipment installed in a vehicle;

Figure 4 is a more detailed block circuit diagram of the data set shown in Fig. 3; and

Figure 5 illustrates a possible time sequence for the interrogation of an active radio beacon.

Fig. 1 illustrates an urban area in which vehicles forming part of a fleet of vehicles are to be located. The locating of the individual vehicles is basically carried out by dead-reckoning navigation, wherein the direction and distance of travel are measured in known manner. This data is generally conveyed via radio apparatus incorporated in the vehicle to a central control station where it is analysed. This analysis central control station can be arranged for example in the fleet central control station FLZ which serves as starting point for all vehicles and thus also represents the first start position for the dead-reckoning navigation.

In specific circumstances the dead-reckoning navigation is corrected by means of additional beacon position finding. However, for such time as a vehicle remains within a homogeneous region of the urban area that is to say, a region within which travel from one location to another is relatively unrestricted—for example in the area A—the accuracy of the dead-reckoning navigation is adequate to ensure that the vehicle is at stand-by in the required manner. This is because in this region A, even in the event of a certain error in the located position from the actual location, any desired location can easily be reached within a short length of time. Circumstances would be different if, due to inaccuracy of the dead-reckoning navigation, it could no longer be safely determined whether the vehicle were located on the one or the other side of the river F, since travel between regions on opposite sides of the river is possible only via a relatively restricted number of routes (i.e. the bridges). For this reason beacons BK2, BK3, BK4 and BK5 are arranged on the bridges. As soon as a vehicle travels over one of the bridges across the river F, it passes by a beacon so that the precise location is safely established and a new start position is obtained for the continued dead-reckoning navigation.

Further beacons BK6, BK7 and BK8 are arranged for example on the arterial roads leading to the suburbs B, C and D. These beacons enable the dead-reckoning navigation to be reset when the vehicle passes from an enclosed urban area into a separate housing estate which is linked only via one road. Similarly, a vehicle leaving the outer area can be included in the inner-city locating system and the radio beacon provides an accurate reference position for the dead-reckoning navigation.

Fig. 2 schematically illustrates the radio traffic to and from the vehicles FZ. The radio telephone traffic with the central control station is handled in the normal manner via radio apparatus contained in the vehicle. In addi-

tion, data are also transmitted from the vehicle to the central control and from the central control to the vehicle and the same frequency is also used for transmitting the location identification from a radio beacon BK positioned on the road to the vehicles FZ.

This additional exploitation of the radio apparatus contained in the vehicle requires only a few additional devices, as shown in Fig. 3. The radio apparatus FG is operated in the conventional manner by means of a telephone set HSG. In order that this radio apparatus may be used for the vehicle position finding, a switch-over device US is provided which allows switch-over from the telephone set to a data set DZU as required. The data set is connected to a dead-reckoning navigation device KN. This dead-reckoning navigation device operates in known manner using a direction-finding sensor and an odometer. The data thus obtained are forwarded to the central control station via the data set DZU and the radio apparatus FG.

Fig. 4 illustrates the more detailed construction of the data set DZU. Here the connection to the radio apparatus takes place via a modem MOD which is of conventional construction. Incoming data for example, a call from the central control is received via the input/output EA. The location identification data received from the beacons when these are passed by is input in the same way via the input EA. From the modem MOD the incoming data pass to a data receiver TE where they are digitalised and fed in suitable form to a processing unit TV. From the processing unit TV, the location identification data of the last beacon to have been passed are input into a store SP. A display device AG is also connected to the processing unit. This can consist of a simple alphanumerical display means, a data viewing device, or a printer. Information received from the central control station, for example relating to the location which has been calculated in the central control station, or general items of information for the driver, are displayed in the vehicle by means of this display device.

A data preparation unit TA serves to emit information from the vehicle to the central control station. For example the location identification of the last beacon to have been passed and the data from the dead-reckoning navigation device KN are input into this data preparation unit. By means of an input device EIN, for example a keyboard, the driver can input further items of information into the preparation unit. All of these items of information are combined in the preparation unit to form a telegram which, on the next occasion when the vehicle is called up, is fed via the telegram transmitter TS and the modem MOD to the radio apparatus FG from where it is transmitted to the central control. Also, a call for interrogation of beacons is set up via the preparation unit and the telegram transmitter. As already mentioned, this call can consist in the transmission of an unmodulated carrier if a passive beacon is in the vicinity. However, such a call-up can also cause an active beacon to emit its location identification.

The switch-over device US can be switched over from data traffic to speech traffic as required via the output AB. Thus no manual operation is required. A switch back from speech traffic to data traffic can then likewise take place automatically at the end of a specific length of time. The individual components of the data set DZU are coordinated via the flow control unit ABL.

In known manner the dead-reckoning navigation device KN comprises an odometer WM and a direction finding sensor RS. In this way a vector describing the path which has been covered in terms of magnitude and direction is in each case formed in the dead-reckoning navigation processing unit KNV. Generally speaking this vector will be forwarded via the preparation unit TA to the central control station where the vehicle location is determined by coupling the individual vectors in combination with the last beacon address to have been received. However, it is also possible to directly calculate the location in the dead-reckoning navigation processing unit KNV of the vehicle. In this case the last beacon address to have been determined is input from the store SP into the dead-reckoning navigation processing unit. Furthermore in this case further items of information can be fed from the central control to the dead-reckoning navigation processing unit KNV the processing unit TV.

Fig. 5 illustrates an example of one possible time sequence of a beacon interrogation process. In this case the beacon is called up by the central control via the vehicle. Thus at the time T1 this call signal *sz* from the central control feeds to the vehicle 1 a command which also contains the beacon interrogation command. Then, at the time T2, the vehicle transmitter emits the beacon interrogation signal *sf* which requests an active beacon to emit its location identification. If a beacon is located within range of the vehicle, at the time T3 it emits its response signal *sb* which contains its location identification. This location identification is recognised in the data set DZU of the relevant vehicle and input into the store SP; with the next telegram this location identification is communicated to the central control station. At the end of the cycle period t_z the interrogation process is repeated, thus the transmission of the call-up signal *sz* to the vehicle followed by the interrogation of the beacon.

CLAIMS

1. A vehicle location system for location of vehicles within an area having regions within

which travel from one location to another is relatively unrestricted but travel between one region and another is possible only via a relatively restricted number of routes, comprising a central control station, a navigation device in each vehicle and operable to determine the direction and distance of travel of the vehicle, radio beacons sited only at positions adjacent said routes whereby whenever a vehicle travels between regions it passes within range of the corresponding beacon, radio apparatus in each vehicle operable to receive identification signals from a beacon when within range thereof and to transmit location information to the central control station, and means, either within each vehicle or in the central control station, operable to continually calculate vehicle location by dead reckoning, using the distance and direction information from the navigation device, relative to a reference position identified by the last beacon (if any) to have been passed, or (if none) a starting position.

2. A system according to claim 1, in which the central control station includes means arranged in operation cyclically to call-up each vehicle in turn, each vehicle including means responsive thereto to transmit the location information to the central control station.

3. A system according to claim 2, in which each vehicle includes means responsive to said call-up to check for the presence of a beacon within range and, if it is present, to receive its location identification.

4. A system according to claim 1, 2 or 3, in which, in each vehicle, a single radio apparatus is employed both for communication with the beacons and for two-way data and speech traffic between the central control station and vehicle.

5. A system according to claim 4, in which both a transmitting channel and a receiving channel are provided, which are employed for both speech and data transmission between central control and vehicles and for communication between vehicles and beacons.

6. A system according to claim 4, in which both a transmitting and receiving channel are provided, on which data is transmitted between central control and vehicles and also between vehicles and radio beacons, whereas speech is in each case transmitted via one or more further transmitting and receiving channel(s).

7. A system according to claim 6, in which the switch-over from the data channel to a speech channel in the vehicle can be effected remotely via the data channel from the central control.

8. A system according to claim 6, in which the switch-over from the speech channel to the data channel in the vehicle is effected automatically at the expiration of a predetermined length of time.

9. A system according to any one of claims 1 to 8, in which the beacons are passive beacons and are interrogated by means of an unmodulated carrier emitted from the individual vehicles, received by the beacon located within the range of influence, and returned modulated with the location identification of the beacon.

10. A system according to claim 9, in which the modulation device of the beacon is arranged to operate continuously.

11. A system according to claim 9, in which the modulation device of the beacons is switched on for short periods of time only by means of a call-up command from the vehicle or from the central control station.

12. A system according to any one of claims 1 to 8, in which the beacons are active beacons arranged to automatically emit their location identification either continuously or at predetermined intervals.

13. A system according to any one of claims 1 to 8, in which the beacons are active beacons arranged to emit their location identification in response to a command from the central control or from a vehicle located within the range of influence.

14. A system according to any one of claims 1 to 13, in which the location identification received from a beacon located within the range of influence is, in operation stored in the vehicle and transmitted to the central control station on the occasion of the next vehicle interrogation.

15. A system according to any one of the preceding claims, in which the means for calculating the vehicle location is located in the vehicle.

16. A vehicle location system substantially as herein described with reference to the accompanying drawings.

17. A method for locating surface-bound vehicles in accordance with the principle of dead-reckoning navigation, wherein, in the vehicle which is to be located, the route vector which describes the path of travel in terms of magnitude and direction is constantly determined, and wherein, in the vehicle in a central control station, the relevant location is determined by coupling the route vectors to a start position, wherein moreover, when passing by specific points in the locating zone, the vehicle is supplied via radio beacons with a precise location identification which serves as new start position for the continued dead-reckoning navigation, characterised in that within the locating zone radio beacons (BK) are only provided at points which are subject to particularly high requirements in respect of locating accuracy, and that the same radio apparatus (FG) is used for the radio traffic between the radio beacons (BK) and the individual vehicle (FZ) and for the radio traffic between the vehicle and the central control, wherein the input/output of the radio apparat-

us contained in the vehicle is selectively connected as required via a switch-over device (US) to a telephone set (HSG) and a data set (DZU).

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